GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
VI – Semester

Course Title: Electrical Drives
(Course Code: 4360905)

Diploma programmer in which this course is offered	Semester in which offered
Electrical Engineering Department	Sixth

1. RATIONALE

Electrical drives lie in their ability to enhance energy efficiency, provide variable speed operation, offer precision control, reduce mechanical stress, enable regenerative braking, adapt to renewable energy sources, facilitate automation, and ensure the safety and protection of systems. These characteristics make electrical drives indispensable in a wide range of industrial, commercial, and residential applications. Today's industrial and domestic loads necessitate precise and smooth variable speed control to meet evolving technological demands. The development of compact thyristor power converters has played a pivotal role in enabling this level of control, particularly in the context of AC and DC motors. This course enables to develop the basics of electric drives and maintain different types of DC/AC drives in industries. Many industries, ranging from manufacturing and automation to transportation and energy, rely heavily on motors and drives for their day-to-day operations. Diploma graduates with expertise in electrical drives are in high demand to ensure the efficient functioning of these critical components.

2. COMPETENCY

Competency in electrical drives involves a comprehensive set of skills and knowledge that empowers individuals to effectively **control, operate, and maintain systems incorporating electric motors and AC & DC drives**. This competency is crucial in various industries where the performance of electrical drives directly impacts the efficiency, reliability, and overall functionality of diverse applications.

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

i. Select drive suitable for a specific application by aligning its power rating with the requirements of the electric motor employed in the system.

ii. Understand the factors influencing the choice between different types of electric motors and its braking and control strategies.

iii. Explain various types of solid-state drives to regulate the speed of DC motors effectively.

iv. Analyze various solid-state drives to regulate the speed of 3 phase induction motor effectively.

v. Differentiate drive-based control strategies for effective working of various special electrical machines.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	2	5	30*	70	25	25	150

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *– Credit,* ***CA*** *- Continuous Assessment;* ***ESE*** *- End Semester Examination.*

5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the sub-components of the Course Outcomes (Cos). Some of the **PrOs** marked **'*'** are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify and list the components of a basic electric drive system.	1	2*
2	Comprehend the basic operational concepts and characteristics of a DC motor.	1	2*
3	Analyze the effect of load on motor behavior	1	2*
4	Compare the characteristics of different types of motors (DC, induction, synchronous).	1	2-4*
5	Simulate the dynamic behavior of the drive system using software tools like MATLAB/Simulink.	2	2-4*
6	Compare the energy efficiency of different control strategies in electric drives	2	2
7	Examine the regenerative braking capabilities in the electric drive.	2	2-4
8	Compare different braking techniques in electric drives	2	2-4*
9	Examine the torque-speed characteristics of an induction motor	2	2*
10	Control the speed of DC motor using armature voltage control method	3	2*
11	Control the speed of DC motor using field control method	3	2*
12	Control the speed of separately excited dc motor using SCR based single phase converter and measure speed variation	3	2
13	Control the speed of DC motor using Step down chopper	3	2
14	Control speed of slip ring induction motor by rotor resistance control method USING VIRTUAL LAB	4	2-4
15	Control speed of single-phase Induction Motor using single phase voltage controller	4	2
16	Control speed of single-phase induction motor using DIAC TRIAC circuit	4	2*
17	Simulate speed control of Brushless DC motor	5	2
18	Examine the behavior of a synchronous motor under different load conditions.	5	2
19	Connect PLC with VFD and control operation using ladder logic program.	5	2-4*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
20	Interface a microcontroller (e.g., Arduino) with a stepper motor to achieve precise position control.	5	2-4
21	Test the performance of solar powered pump drive	5	2-4*
22	Discuss the impact of harmonics on motor performance and the measures to mitigate them.	5	2
	Minimum 10 Practical Exercises		56

Note

*i. More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

*ii. The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.*

Sr. No.	Sample Performance Indicators for the Pros	Weightage in %
1	Understanding of concepts	20
2	Explanation of conclusion	20
3	Student attitude towards learning	20
4	Quality of term work	20
5	Timely completion of term work	20
Total		**100**

5. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to user in uniformity of practicals in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	DC supply 400-volt, 10 Ampere	2,4,10,11,12,13
2	Single phase and three phase AC supply system	3, 7 to 21
3	Single phase and three phase Variac 0 – 400 Volts	3,15,17,20,
4	Mechanical braking system	8
5	Electrical Dynamic braking system	7,8,
6	Chopper based trainer kit for dc motor control	10,11,13
7	Standard rating DC motor with load and coupling system	2,10,11,12,13
8	Standard rating AC 3 phase slip ring induction motor with load and coupling system	4,14
9	Standard rating synchronous motor with load and coupling system	4,18,19
10	Standard rating stepper motor and PLC	19,20
11	Standard rating BLDC motor	17
12	Overload protection, over-temperature protection, short circuit protection.	1 to 22
13	Programming and simulation softwares.	3,4,5,6,8,9,14,17,19,20,22

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
14	Emergency stop, fault detection, protective enclosures.	1 to 22

6. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfill the development of this course competency.

a) Work as a leader/a team member (while doing a micro-project)
b) Follow safety practices while using Electrical supply and electrical equipment.
c) Follow ethical practices.
d) Adhere to safety protocols to ensure the safe installation and maintenance of system.
e) Practice environmental friendly methods and processes. (Environment related)

The ADOs are best developed through the laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.
iv.

8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required,ore such UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit – I **Basics of Electrical Drives**	1a. Illustrate the operation of an electrical drive using a clear block diagram for a comprehensive understanding of its functioning. 1b. Justify the selection criteria for electrical drive(s) 1c. differentiate various type of industrial load and types of drive 1d. Use heating and cooling curve for finding temperature rise in a drive. 1e. Select a motor on the basis of duty cycles of motors. 1f. Selection of power rating of motors. 1g. Select electric drives for a given application.	1.1 Electric drive, types, AC v/s DC drives, choice of electric drives. 1.2 Factor influencing choice of electrical drive. 1.3 Parts of electrical drive-Source, power modulator, electric motor and control unit. 1.4 Different types of industrial load and drives 1.5 Heating and cooling curve 1.6 Motor duty class, classification– continuous, short time, intermittent periodic with industry relevant example. 1.7 Motor power rating for continuous, short time and intermittent duty, equivalent current, torque andpower methods for fluctuating and intermittent loads. 1.8 Selection of electric drive for applications: agricultural pumps, steel mills, paper mills, rolling mills, spinning mills.

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit-II Dynamics of Electrical Drives	2a. Explain the nature of speed torque characteristic of various types of loads and drive motors with the help of neat sketch. 2b. Explain the multi quadrant operation of electrical drive. 2c. Describe different methods of braking used in any electric drive. 2d. Describe the basic concept of various control loops used in electrical drives.	2.1 Steady state load Torque speed characteristics 2.2 Multi quadrant operation of drives 2.3 Types of Braking-(a) Plugging, (b) dynamic/rheostat braking and (c) regenerative braking. 2.4 Starters-Typical control circuits for shunt and series motors, three phase squirrel cage and slip ring induction motors. 2.5 Close loop control of drives a. Current limit control b. Close loop torque control c. Close loop speed control d. Close loop speed control of multi motor drive
Unit-III DC Drives	3a. Explain conventional speed control technique(s) of DC motors. 3b. Explain various solid state speed controls of single and three phase DC drives. 3c. Describe the speed control of chopper-controlled DC drives.	3.1 Speed control of DC series and shunt motors – armature and field control. 3.2 Solid state speed control of single phase and 3 phase DC drives with the following i. Half wave converter ii. Semi converter iii. Full converter iv. Dual converter 3.3 Solid state speed control of separately excited shunt and series motor drives 3.4 Chopper control drive.
Unit-IV AC Drives - Three Phase Induction Motor Drive	4a. Explain speed control methods of a 3-phase induction motor. 4b. Explain the working of various 3 phase induction motor drives for precise variable speed control.	4.1 Basic principle of 3 phase induction motor drive. 4.2 Solid state control of 3 phase induction motor: i. Stator voltage control of 3 phase AC voltage controller and soft start. ii. Speed control of Induction motor using Voltage source inverter. iii. Static rotor resistance control of induction motor. iv. Slip recovery scheme using static Kramer drive. v. Speed control of single-phase induction motor using DIAC and TRIAC device vi. Speed control of 3 phase induction motor by various connection method of Variable Frequency drive. a) VFD to Motor direct connection b) Speed Control of motor using PLC
Unit– V	5a. Describe the working of	5.1 Working of brushless DC motor 5.2 Stepper motor drive and its application.

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Drives for Advanced Electrical Machines	various advance electrical machines drives. 5b. Explain the working of solar powered pump drives. 5c. Explain the working of battery powered electrical vehicles.	5.3 Servo Motor drive and its application. 5.4 Drive for switched reluctance motor solar powered pump drive. 5.5 DC drives with chopper control for electrical vehicle.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Basics of Electrical Drives	08	06	06	02	14
II	Dynamics of Electrical Drives	06	02	04	04	10
III	DC Drives	10	06	04	06	16
IV	AC Drives- 3 Phase Induction Motor Drives	12	06	06	06	18
V	Drives for Advance Electrical Machines	06	04	04	04	12
Total		42	24	24	22	70

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*
Note*: This specification table provides general guidelines to assist students for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions to assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may slightly vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course. Students should perform following activities in group (or individual) and prepare reports of about 5 pages for each activity. They should also collect/record physical evidences for their (student's) portfolio which may be useful for their placement interviews:

i. Prepare journals based on practical performed in laboratory.
ii. Visit websites of suppliers of electric drives and do a comparative study of differentdrives provided by different companies.
iii. List various motor controlling parameters and find how they affect the performance of motor and drives.
iv. Find troubleshooting techniques and steps to troubleshoot DC drives.
v. Simulate various DC motor drives.
vi. Analyze the specifications for various types of AC drives.
vii. Find practical applications of AC drives in home appliances and list variousParameters of those applications.
viii. Make comparative table for various drives based on its application and maximumpower ratings.

ix. Check the performance of at least two different types of drives using simulationsoftware like MATLAB.
x. Implement real-time monitoring and data logging for key parameters (speed, current, voltage) in an electrical drive system. Use this data for performance analysis.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

i. Show video/animation film to demonstrate the working principles, constructionalfeatures, testing and maintenance of different types of DC motor drives.
ii. Arrange expert lectures by engineers working in electric drive companies.
iii. Arrange a visit to nearby manufacturer of electrical drives.
iv. Evaluate the challenges and benefits of using renewable energy in drive applications.
v. Use flash/animations to explain the working of different control devices.
vi. Arrange expert lectures on recent trends in electrical drives in industry.
vii. Give mini projects to students.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-projects are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The duration of the micro project should be about **14-16 *(fourteen to sixteen) student engagement hours*** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) Develop model for simple electric drive.

b) Create a mechanism for braking system in dc motor.

c) Make working model of Wind Turbine using appropriate Electrical drive.

d) Prepare Arduino based BLDC motor Controller

e) Measure and analyze the impact of tracking system for solar panel.

f) Prepare comprehensive chart including all Electrical drives with one industrial application

g) Design a changeover in solar-powered water pumping system.

h) Develop fine control in stepper motor.

i) Develop fine tuning in VFD for smooth speed operation.

j) Obtain data of harmonics in motor controlled by electric drive.

13. SUGGESTED LEARNING RESOURCE

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1.	Fundamental of Electric Drives	G K Dubey	New Age Publication
2.	Power electronic and its application	Alok Jain	PEN Ram 2016, 978-81-879-7261-7
3.	Electric Drives and application	Vedam Subramanyam	Tata McGraw-Hill Education
4.	Elementary concepts of Power Electronic Drives	K. Sunderswaran	CRC press
5.	Fundamental of Electric Drive and control	B R Gupta V Singal	Katson Publication

13. SOFTWARE/LEARNING WEBSITES

- **https://people.ece.umn.edu/users/riaz/**
- **http://vlabs.iitkgp.ernet.in/vlabs/**
- **http://ied-nitk.vlabs.ac.in/**
- **https://www.integrasources.com**
- **https://www.classcentral.com/course/swayam-fundamentals-of-electric-drives-14073**

14. PO-COMPETENCY-CO MAPPING:

Semester IV	Solar Photovoltaic (Course Code: 1346401)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solution	PO4 Engineering Tools, Experimentation Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency	To help individual to understand their role and responsibilities for depth Understanding of Solar Photo Voltaic system						
i. Select drive suitable for a specific application by aligning its power rating with the requirements of the electric motor employed in the system.	2	--	1	--	2	1	1
ii. Understand the factors influencing the choice between different types of electric motors and its braking and control strategies.	2	2	--	2	2	1	2
iii. Explain various types of solid-state drives to regulate the speed of DC motors effectively.	2	1	--	2	--	-	--
iv. Analyze various solid-state drives to regulate the speed of 3 phase induction motor effectively.	2	1	--	2	--	--	--
v. Different drive-based control strategies for effective working of various special electrical machines	2	1	2	1	--	--	1

*Legend: '**3**' for high, '**2**' for medium, '**1**' for low and '**-**' for no correlation of each CO with PO.*

15. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

S. No.	Name and Designation	Institute	Contact No.	Email
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